MANUFACTURING PROCEDURES AND PRODUCT CHARACTERISTICS OF THE WISCONSIN LAMB ROLL

Agricultural Development and Diversification Grant No. 14046

(Wisconsin Lamb Roll – Second Generation)

FINAL REPORT

Sandy Russell
Cazenovia, Wisconsin

Mehmet Calicioglu and Dennis R. Buege
Meat Science and Muscle Biology Laboratory
University of Wisconsin, Madison

October 2001

Foreward

The Wrap-Up of the Roll-Up

At the close of our Wisconsin Lamb Roll Year 1 project, we were pleased to observe that the idea of the lamb roll represented one of the few totally exciting and positive elements in the Wisconsin sheep industry. The product was introduced to chefs, processors and food service with a good share of positive response. Probably the highest form of compliment would be to have the product copied by others as the "original" Wisconsin Lamb Roll - - and that happened, too.

One sure sign that the Wisconsin Lamb Roll has made an impact on a traditionally resistant beef-pork-chicken biased public will surface in 2002, when the Lamb Roll will be served at the Wisconsin Farm Progress Days to be held in Richland County. Even though the Lamb Roll grant term will be long concluded by then, we will be anxiously awaiting the public's response to the flavor and appeal of lamb. This exposure should continue our first year's objective to change consumer perception of lamb as a difficult and costly chop-roast-sausage offering into exactly what the lamb roll is: A muscle-dense, defatted, netted and completely usable product.

The Wisconsin Lamb Roll Project has been candidly called the only "Up Thing" that has blossomed in the sheep industry in Wisconsin in ten years. Producers have been hugely supportive, re-enchanted in their enterprises, and anxious to cooperate. It is hoped that Wisconsin's some two thousand lamb producers, representing over twenty-five different breeds of sheep, and with limited production numbers in any one unit will benefit from this processing technique. The lamb roll has utilized lean lambs of a lighter weight, thus not requiring overly long periods for lambs to be kept on feed to simply add pounds of fat. Our hope is that the development of the lamb roll and the continued use of it by the sheep industry will assure the Wisconsin Department of Agriculture, and its Development and Diversification Program, that its trust in us was well placed. The information which the University has added to the sheep industry through the guidance of Dr. Dennis Buege and his staff should be of great help in clarifying lamb's nutritional constituents, its safe handling parameters and protocols – not only for the Wisconsin Lamb Roll, but for lamb as a consumer meat choice option.

Sandy Russell
Cazenovia, Wisconsin

Table of Contents

Wisconsin Lamb Roll Final Report

Listing of Tables, Figures and Attachments

Tables:

Figures:

Attachments:

PROJECT LEADERS

Sandy Russell has been raising sheep for 46 years. In 2001 she received the "Purebred Shepherd of the Year" award from the Wisconsin Sheep Breeders Coop, for the development of the Wisconsin Lamb Roll. Her address and phone number are: 18256 County NN, Cazenovia, WI 53924. Tel: 608-647-7351

Mehmet Calicioglu was a graduate student in Meat Science at the University of Wisconsin-Madison, when this work was conducted. His background in lamb products from his native Turkey was a valuable asset in this project.

Dennis Buege is a Professor and Extension Meat Specialist in the Department of Animal Sciences at the University of Wisconsin-Madison. He may be reached at: Meat Science Lab, 1805 Linden Drive West, Madison, WI 53706, Tel: 608-262-0555, Fax: 265-3110, email: drbuege@facstaff.wisc.edu

ACKNOWLEDGEMENTS

Appreciation is expressed to the following individuals and groups for their important assistance in conducting this project.

Wisconsin Department of Agriculture, Trade and Consumer Protection for providing the funding to conduct this work.

Erik Russell, for his assistance in fabricating the Wisconsin Lamb Rolls used in this project.

Bill Blake, for his advice and insights into this product, and for assistance in fabricating the lamb rolls used in Study 2.

Bob Black, for his overall project advice, assistance in preparing the grant, and for providing the lambs for Study 1; and to his Madison Area Technical College "Sheep Production" class for its helpful input into the product.

Terry Timm, for his assistance in slaughtering the animals, and fabricating/processing the lamb rolls.

Lyle Roe, for his interest in the project, and for procuring the lambs for Study 2.

Dave Thomas, for his input, and for the evaluation of the lamb roll by his University of Wisconsin "Sheep Production" class.

Chef Paul Short, and his Madison Area Technical College "Culinary Arts" class, for their input and evaluation of the Wisconsin Lamb Roll.

Sung Jun Jang, for his assistance in conducting the sensory analysis of lamb rolls, and analysis of the panel results.

Mike Bandli, for his support of this project, and patience in awaiting the final report.

Laura Trumble and **Susan Porter,** for their skillfull assistance in helping to prepare this final report.

Executive Summary:

Study 1 and Study 2 in this project followed up on early development work by the initiators of the Wisconsin Lamb Roll, Sandy and Patrick Russell. Lamb rolls are produced by splitting chilled lamb carcasses into halves, removing all bones, and rolling the boneless side into one symmetrical roast (12 to 17 pounds in weight). This product markets virtually the entire lamb carcass as one product, is convenient to prepare and serve, and provides a larger size lamb product for buffet lines and large gatherings.

A total of 12 carcasses were used in the studies, providing 24 lamb rolls which were subjected to various treatments. Steps in the manufacturing process were documented, and a video tape demonstrating the process was created. Fabrication tests revealed that the yield of lamb rolls from chilled lamb carcasses averaged about 55% of carcass weight, with about 12% of the carcass weight as additional edible trim. The remaining inedible components consisted of bone, fat and connective tissue.

Treating lamb rolls with "binding agents" (Fibrimex and Transglutaminase) greatly improved "intactness" (muscles adhering together) within cooked sliced product, compared to conventional (control) lamb rolls. In addition, rolls treated with either binding agent had approximately 10% greater cooked yield than control lamb rolls (80% for control rolls vs. 90% for treated rolls).

Sensory panel analysis of control, Fibrimex-treated and Transglutaminase-treated lamb rolls subjectively confirmed the ability of the two binding agents to greatly improve the intactness of cooked slices, over those from untreated rolls. The panels rated the treated lamb rolls superior in juiciness (probably due to their 10% higher cooked yield), but found no difference between the three types of rolls in tenderness, flavor or overall acceptability.

Cured and smoked lamb rolls were manufactured by incorporating 10% brine into the meat by means of a tumbling and equilibration process, followed by thermal processing in a smoke house. Slices of cured and smoked roll had excellent "intactness", due to the

binding action of salt-soluble muscle proteins extracted during the tumbling procedure. This was an excellent product which a sensory panel rated similar in overall acceptability to a premium boneless commercial pork ham. The cured and smoked version would provide an alternative product, differing in color, flavor and taste, to augment the traditional fresh lamb roll.

Fresh lamb rolls were cooked by roasting for three hours to a final internal temperature of 145°F, according to a previously developed procedure. Cured and smoked lamb rolls were processed according to a 10 hour schedule to 155°F internal. Product temperature information collected during both cooking procedures provided an evaluation of the microbial lethality of thermal treatments, verifying their adequacy to destroy a prescribed level of pathogens which could be potentially present in the interior of the roll.

Three control lamb rolls were analyzed for nutrient content, to collect information for possible nutritional labeling. In general, cooked, trimmed lamb rolls are similar to other lamb products in important meat-related nutrients. However, the lamb rolls tested were slightly higher in total fat than most lamb cuts, presumably due to the retention of melted fat, arising from deposits within the roll, which is trapped within the product and absorbed by the lean.

A challenge to acceptance of the Wisconsin Lamb Roll is the lack of uniformity between the two ends of the roll. The leg-end tends to be quite lean and displays little trimmable fat. Conversely, the shoulder-end displays much more seam fat. Although reducing this anatomical variation was not resolved in this project, we believe it can be minimized through proper lamb selection (utilizing lighter, lean lambs) and by paying close attention to trimming of fat during manufacture of the lamb rolls.

Taking into account product yields determined in these tests, and current industry processing charges, and with a live lamb credit of $0.80 per pound, the estimated break-even price for a lamb roll was calculated to be $4.37 per pound. If binding agents (Fibrimex or Transglutaminase) were used to improve slice intactness, the cost of

producing the roll would increase by $0.15 to $0.20 per pound. Curing and smoking, with its added time investment and cost of thermal processing (but greater yield of saleable product), would probably increase the lamb roll cost by $0.25 to $0.50 per pound.

I. Project Introduction and Perspective

In the mid-1990s Patrick and Sandy Russell developed the concept of the "Wisconsin Lamb Roll" to offer the food service industry, retailers and consumers a new value-added lamb product, which is easy to prepare and serve. It also provides a larger size lamb product than is currently available, to be useful for serving large group gatherings and in food service buffet lines. The addition of value in this new method of merchandising lamb is also aimed at increasing economic returns to sheep producers who are able to take advantage of marketing their animals in this manner.

The concept itself is quite simple – remove all bones from a lamb carcass side, and roll it into one fairly symmetrical roast, weighing from 12 to 17 pounds. This approach is in contrast to the typical methods of merchandising and marketing lamb, which provide a large array of different cuts, most of which are small in size, owing to the inherent small size of the sheep carcass. The purpose of the Wisconsin Lamb Roll is not to replace traditional merchandising methods, but to augment them by offering a new value-added alternative which has distinct advantages for various market segments.

While the concept is simple and straightforward, there are a number of challenges involved in producing and marketing this product. Since the single resulting product is the reflection of the properties of the entire lamb carcass, the types of animals used need to fall within certain specifications to provide an acceptably uniform end product. The fabrication of the carcass side requires appreciable processor skill to effectively and efficiently remove the bones, trim excess fat and roll the resulting side into a uniform and attractive lamb roll. As with any new product, there is the need to expose the item to potential customers, to teach its preparation and use, and to monitor the feedback of end users to guide further development and modification of the product.

As part of the development process for this product, Patrick and Sandy Russell received an initial Agricultural Development and Diversification Grant (ADD Grant) from the Wisconsin Department of Agriculture, Trade and Consumer Protection. This allowed for early development of the product, and initial production runs to place the product into the

hands of potential end users. It also provided for exposure of this product to various groups around the state through informational/tasting sessions. These efforts generated substantial positive feedback and encouragement about the potential for this new product, but also raised some issues. They invited additional investigations to further define the manufacturing process and product properties, and accumulate broader evaluation of the product. Attachment 1 is a copy of the color flyer developed to introduce the Wisconsin Lamb Roll.

The work outlined in this report was done in conjunction with a second ADD Grant obtained by Sandy and Patrick Russell to further develop, define, modify and evaluate the Wisconsin Lamb Roll. Unfortunately after the grant was awarded Patrick suffered a stroke, which left him seriously handicapped, and unable to contribute to this work. This report presents the findings and observations collected on the Wisconsin Lamb Roll in studies conducted by Dennis Buege and Mehmet Calicioglu of the Meat Science and Muscle Biology Laboratory at the UW-Madison, in conjunction with Sandy Russell, in fulfilling that ADD Grant objectives. The accomplishments documented include:

1. Describing the fabrication steps in converting a lamb carcass side into a lamb roll.
2. Creating a video of the fabrication process.
3. Evaluating two binding agents designed to improve lamb roll intactness (muscles adhere together after cooking and slicing).
4. Developing a cured and smoked lamb roll, as a companion product to the fresh lamb roll.
5. Determining if the oven roasting process developed for fresh lamb rolls, and the smokehouse cooking procedure used in producing cured and smoked lamb rolls, provide adequate thermal destruction of pathogens potentially present in the interior of the product.
6. Evaluating the properties and acceptability of fresh lamb rolls, and cured and smoked lamb rolls, by a sensory panel and through focus-group sessions with various audiences.
7. Determining the nutrient content of the Wisconsin Lamb Roll.
8. Estimating the economics of producing the Wisconsin Lamb Roll.

The information was gathered in two separate studies. **Study 1** (a preliminary trial) was initiated in September, 1999. **Study 2** commenced in May, 2000.

II. Wisconsin Lamb Roll – Study 1 (Fall 1999)

Study 1 was a preliminary trial to learn more about the process of producing lamb rolls, and to document the production steps in its manufacture. In addition, some customers previously evaluating the lamb roll noted that the cooked product fell apart into individual muscles upon slicing. While this was not necessarily a major problem, we treated several rolls with a binding agent (Fibrimex) to determine its affect on slice integrity of cooked lamb rolls. We additionally subjected several rolls to a curing and smoking process to determine its effect on the product. Lastly, one roll was cooked and analyzed for nutrient content.

A. Slaughter and Fabrication:

Four lambs, 6 months old were slaughtered at the Meat Science Laboratory of the University of Wisconsin-Madison. Carcasses were chilled for 24 hours at 38°F. Average weight loss of the lamb carcasses at the end of chilling was 2%. The chilled carcasses were divided into halves by cutting on a band saw, and then boned in an average of 50 minutes (total for both sides - ranges from 25 to 70 minutes). Half weights varied from 28 to 34.5 pounds. At the end of the boning process, weights of the eight lamb rolls ranged from 14.5 to 17 pounds (average = 15.28 $\pm$ 0.96 pounds) with a boning yield range of 47.0 to 56.4% (average = 53.8 $\pm$ 3.23%). Percentage yields of edible and inedible trim from the lamb halves were 8.9$\pm$3.6% and 38.13 $\pm$ 6.12%, respectively.

B. Description of Fabrication Procedure:

During both **Study 1** and **Study 2** attention was given to documenting the individual steps involved in converting a lamb carcass into lamb rolls. Attachment 2 provides a detailed description of the steps followed by Erik Russell (son of Sandy and Patrick), an experienced meat processor, in producing the Wisconsin Lamb Roll. Undoubtedly other skilled processors might follow somewhat different procedures in producing a similar lamb roll. However, whatever techniques are employed, proper attention must be given to important details in order to produce a high quality lamb roll. A potential marketing problem could result if variable processing methods result in inconsistent and inferior product, damaging the overall image of this product.

Video tape footage was collected of the process in both studies, and has been edited to produce a visual description of the process which can serve to guide others interested in producing this product.

C. Treatments Applied to Lamb Rolls:

The 8 lamb rolls produced from the four carcasses were treated as follows:

1 control lamb roll (original process – later cooked, trimmed and submitted for nutrient analysis).

4 lamb rolls were treated with Fibrimex.

3 lamb rolls were cured and smoked.

D. Application of Fibrimex:

Fibrimex is a blood component-based system effective in binding together meat surfaces. It was obtained from FNA Foods, Inc., Calgary, Alberta (Canada). That company's description of the product states: "Fibrimex is a 100% natural fresh meat binding medium. Its performance is based on the formation of a fibrinogen network activated by the enzyme thrombin. Both fibrinogen and thrombin are meat proteins that are extracted naturally. The application of Fibrimex is simple. The two proteins are mixed proportionately and applied to coat the surface of fresh meat portions, which then may be placed into a desired form. Fibrimex is approved by the USDA, FDA and Agriculture Canada for use with all species of meat, poultry, fish and seafood."

Frozen fibrinogen and thrombin products were thawed for one hour prior to application, following the manufacturer recommendations. Individual parts of 1:20 of thrombin:fibrinogen were combined just before addition to the meat. Once these two components are combined, the mixture must be used within 15 minutes. Using a 5-inch plastic paintbrush, the mixture was applied to entire outer and inner surfaces of the deboned lamb side. The treated side was immediately folded into a lamb roll. Resulting rolls were placed in a 38^{o}F cooler overnight.

E. Preparing Cured and Smoked Lamb Rolls:

Following deboning, 3 lamb sides were placed into a meat tumbler (rotating drum) along with an amount of curing solution equal to 10% of the meat weight. A standard ham curing solution was used, consisting of water, salt, sugar, sodium tripolyphosphate, sodium erthorbate and sodium nitrite. The tumbling process consisted of 6 cycles, each with 15 minutes of rotation and 15 minutes of rest, carried out in a 38°F cooler. Tumbled lamb sides were held at 38^{o}F for an additional 72 hours to allow for cure equilibration. Cured lamb sides were then rolled, netted, weighed, and placed on horizontal racks in the smokehouse for smoking and cooking. The smokehouse program is summarized in Table 1.

The cooking and smoking process was completed in 10 hours. Products were chilled in a 40^{o}F cooler overnight, and then weighed and sliced. One of the lamb rolls was cooked with a DATAtrace probe placed into its center. This probe recorded the temperature change in the center of the roll every 10 minutes during cooking. The probe was removed from the lamb roll after cooking and read by a computer program. The program calculated the F-value for the process, an indication of bacterial kill in the center of the roll (slowest heating point) during cooking.

F. Roasting Method:

One Fibrimex-treated roll and one control roll were roasted in a conventional oven. The cooking procedure used was developed by the Russells during the early stages of product development. Cooking was carried out at 450^{o}F for 30 minutes uncovered, and then at 300^{o}F covered with aluminum foil, to an internal temperature of 145^{o}F. Internal temperature of the roast was monitored by a thermocouple during cooking. A DATAtrace probe was also inserted into the center of the roast to collect temperature information for calculating the F-value (process lethality). Unfortunately, the probe did not work properly because of a programming error. The roasting procedure was completed in approximately 3 hours. Internal temperature of the lamb roll was found to increase by 5^{o}F after removal from the oven. The product was allowed to cool to an

internal temperature of approximately 130^{o}F prior to slicing. The visual degree of doneness was in the "medium" range (pink interior).

G. Cooking Yields of the Lamb Rolls:

Cooking yields from the three treatment groups are shown in Table 2. There was about a 10% yield difference between Fibrimex-treated and cured and smoked rolls, and control rolls not treated with a binding agent. The binding together of the muscles (as well as the added salt in the cured and smoked rolls) more effectively trapped or held-in moisture during cooking, providing significantly higher cooked yields over non-bound rolls. This has potential economic and palatability consequences.

H. Binding Integrity of Lamb Roll Slices:

Binding integrity of 1-inch slices from roasted control and Fibrimex-treated lamb rolls, and from cured and smoked lamb rolls, were visually evaluated and photographed. Both treatments were clearly different from untreated control lamb roll in binding together muscles within a slice (see Attachment 3). Fibrimex was very effective in binding the product together in the uncooked state, resulting in slices that remained intact through cooking and slicing. This was much different than control cooked roll in which individual muscles readily separated upon removing the netting and slicing.

The curing/tumbling/smoking process also resulted in lamb rolls that were firmly bound together, yielding intact slices. During the tumbling process added salt solubilizes and extracts muscle protein from lean surfaces. This extraction is enhanced by the mechanical action of the tumbler (working the salt into the meat). The extracted protein is the glue that binds together adjacent pieces of lean during cooking. In contrast to Fibrimex which binds muscles together even in the cold state, the curing/tumbling process requires heat to "set" the extracted proteins and provide a good bind.

I. Variation in Composition Within Lamb Rolls

Visual evaluation of one-inch slices across the entire length of the lamb roll revealed appreciable variation in distribution of fat and lean tissue between the two ends of the

product. Slices from the leg end contained very little seam fat, while slices from the shoulder end contained large amounts of seam fat (Attachment 4).

Table 1. Summary of cooking and smoking procedure for Wisconsin Lamb Rolls.

Time	Dry Bulb (^{o}F)	Wet Bulb (^{o}F)	RH[1]	Dampers	Smoke
1 hr	150	0	--	open	--
30 min	155	0	--	open	--
2 hr	165	120	26%	closed	on
1 hr	180	140	30%	closed	on
to 155^{o}F internal	185	160	54%	Auto	--

[1] Relative humidity.

Table 2. Summary of yields of lamb rolls – carcass to cooked products.

Sample	Treatment	Half Carcass Weight (lbs.)	Boneless Roll Weight (lbs.)	Lamb Roll Yield From Carcass (%)	Wt. Before Cooking (lbs.)	Wt. After Cooking (lbs.)	Cooked Yield (%)

14-L	Control[1]	28.2	15.4	54.8	15.3	12.2	79.7
14-R	Fibrimex[1]	27.7	15.1	54.5	14.9	13.6	91.3
16-R	Smoked/cured[2]	26.8	15.1	56.5	16.8	15.0	89.3
17-R	Smoked/cured[2]	34.6	16.3	47.2	17.8	16.2	91.0
17-L	Smoked/cured[2]	30.3	17.0	56.1	18.4	16.6	90.2

[1] Cooking of these products was roasting in oven.
[2] Cooking of these products was heating and smoking in smokehouse. Increase in the "Wt.
Before Cooking" reflects the uptake of curing brine.

The leg consists of four major muscle groups, which usually contain little trimmable fat (seam fat) between muscles. Therefore, the leg end of the lamb roll presents a lean, meaty appearance. The lamb shoulder contains many small muscles, which are prone to accumulate seam fat between muscles. Therefore, the shoulder end of the lamb roll displays much more waste fat in slices. In cooked rolls served hot, the seam fat is less noticeable, as it is partially melted, and some can be trimmed away by the server. However, in chilled conventional lamb rolls and cured/smoked lamb rolls excess seam fat in the shoulder end is readily apparent, and can give a fatty appearance to the product.

This compositional difference between the shoulder and leg ends of lamb rolls will always be a consideration. It is inherent in the lamb's musculature. However, we believe the contrast can be minimized by starting with the proper lamb (less external finish and less seam fat) and by paying attention to thorough trimming of seam and external fat in all areas of the carcass. This problem might also be addressed in some situations by cutting lamb rolls in half, and merchandising leg and shoulder ends separately to different clientele who prefer one end or the other. Undoubtedly the presence of greater seam fat in the shoulder end of the roll, while increasing its fat and calorie content, also enhances juiciness and flavor in the cooked product.

J. Microbial Lethality of Cured and Smoked Lamb Roll Process

The cumulative F-value (process lethality) determined for the curing and smoking process was approximately 5000 (Attachment 5). The F-value required in a heating process to provide for a 7 log kill of *Salmonella* and *E. coli* 0157:H7 (inactivate 10,000,000 cells per gram), and a 4 log kill for *Listeria monocytogenes* (inactivate 10,000 cells per gram) is approximately 5. Therefore, the calculated F-value of almost 5,000 indicates a huge bacterial kill in this low temperature/long time heating process, assuring that the cooking employed was far more than adequate to destroy any pathogens which may have contaminated the interior of the roll.

III. Wisconsin Lamb Roll – Study 2 (Spring 2000)

Valuable experience was obtained and information collected in **Study 1**. **Study 2** was a more extensive study designed to confirm and build on the findings of **Study 1**, and to extend evaluation of the product with formal sensory panels, input from chefs, and several consumer experiences. Additional information was collected on the nutrient content of the Wisconsin Lamb Roll.

Study of the improved binding within rolls in **Study 1**, provided by Fibrimex and the curing/tumbling/smoking process, was expanded in **Study 2** with the addition of a treatment utilizing another binding agent, Transglutaminase. Transglutaminase is an enzyme found widely in plants and animals. It catalyzes the polymerization and crosslinking of proteins (binding) under a wide range of temperature conditions. Transglutaminase is commercially manufactured by a microbial fermentation process, and its safety has been established in a variety of tests.
A potential advantage of Transglutaminase application is that it comes in powder form and is merely sprinkled onto the meat surfaces to be bound together. Fibrimex use is more complicated, requiring thawing of the two frozen components (thrombin and fibrinogen), mixing them together, and then applying to the meat within 15 minutes of their combination.

To provide insight from the perspective of a highly knowledgeable, experienced veteran of the lamb industry, Bill Blake was invited to evaluate the lamb roll process and product, and to assist in their fabrication in **Study 2**. Bill lives in the Detroit area and has been involved in teaching merchandising and cooking techniques for retailers and food service personnel for over 40 years.

Attachment 6 presents photos related to the manufacture of Wisconsin Lamb Rolls in this project.

A. Slaughter and Fabrication:

Eight lambs, purchased from Equity Livestock Marketing Cooperative, were slaughtered at the Meat Science and Muscle Biology Laboratory. Lamb carcasses were chilled in a

similar manner as described for **Study 1**. After 48 hours chilled lamb carcasses were split into halves and then deboned and rolled as described in Attachment 2.

B. Fabrication Yields of Lamb Rolls:

Percentage yields collected during deboning and cooking are summarized in Table 3. Carcass trim was separated as edible and inedible parts. Edible trim included shanks and any lean trim such as the diaphragm muscle. Inedible trim included bone and fat, and has no economic value. The inedible percentage can be reduced by selecting appropriate lambs for the rolls, ideally leaner and smaller in size (e.g., 100 lb live weight), yielding less waste fat.

Average boning yields from **Study 1** and **Study 2** were fairly consistent, and provide a baseline of expected values for cost estimations for the Wisconsin Lamb Roll.

	% Boneless Roll	% Edible Trim	% Inedible Trim
Study 1	53.8	8.9	38.1
Study 2	55.3	11.9	35.8

C. Treatments Applied to Lamb Rolls:

Four boneless lamb rolls were randomly assigned to each of the following 4 treatments (Figure 1).

Control: The boneless lamb side was rolled with no other treatment applied (original process).

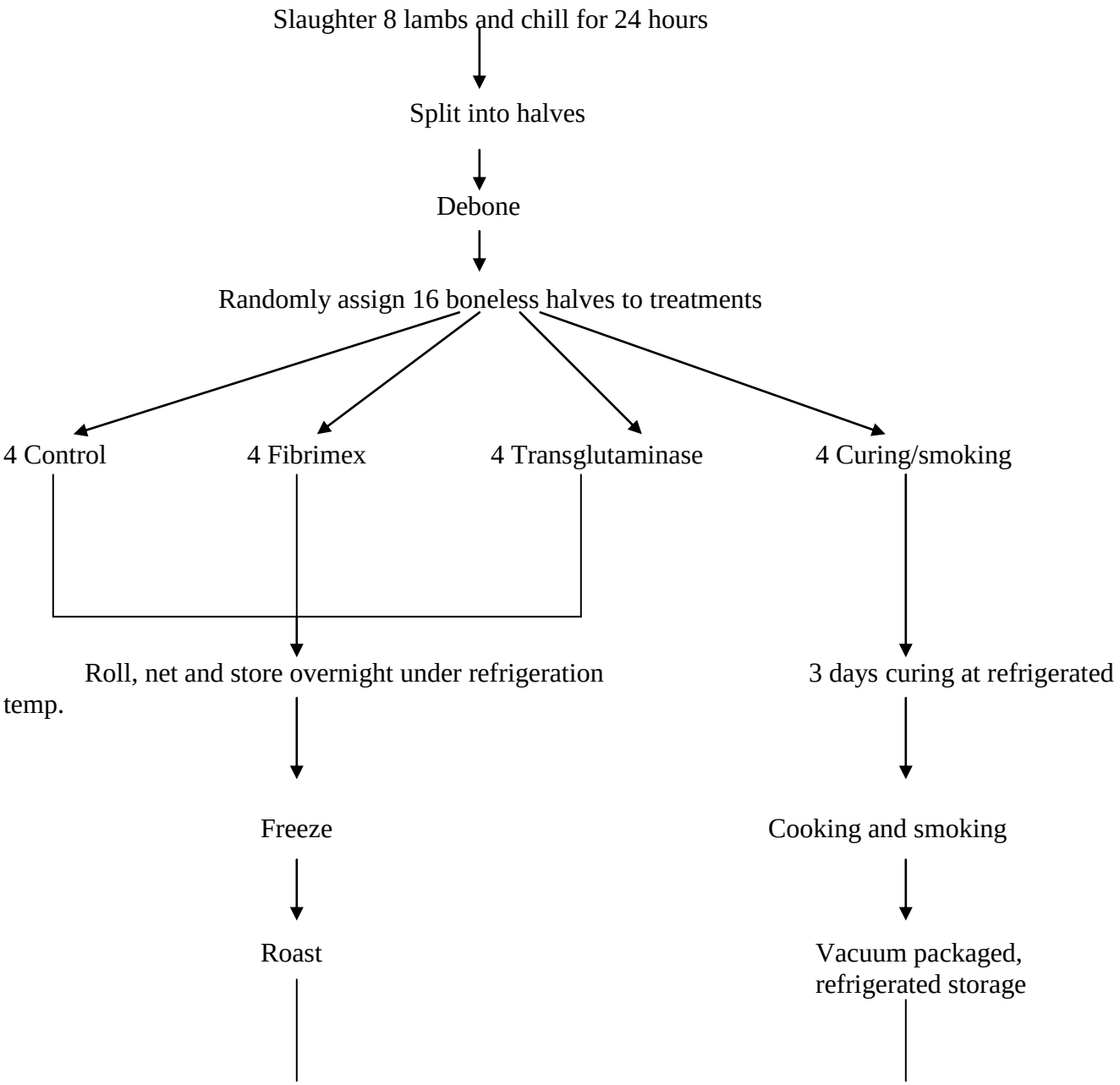
Fibrimex: Frozen fibrinogen and thrombin products (Fibrimex, FNA Foods Inc., Calgary, Canada) were thawed 1 hour prior to application, following the manufacturer's recommendations. Thrombin:fibrinogen were combined in a 1:20 ratio just before application to lamb rolls. Using a 5-inch plastic paintbrush, the mixture was applied to entire outer and inner surfaces of the deboned lamb sides, followed by immediate rolling. Resulting rolls were then placed in a 38°F cooler overnight, prior to freezing. The amount of Fibrimex applied was equal to 1% of the boneless lamb side weight.

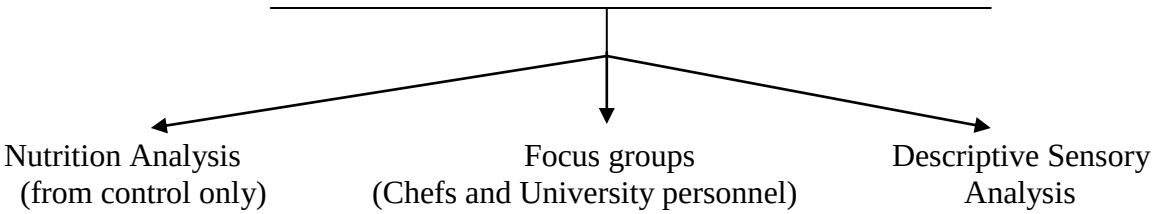
Transglutaminase: Transglutaminase powder (Activa RM, Ajinomoto USA Inc., Teaneck, NJ), a meat-binding enzyme, was applied at 0.7% of the boneless lamb side weight by sprinkling onto the entire outer and inner surfaces of deboned lamb sides.

After immediate rolling, lamb rolls were stored at 38°F overnight as manufacturer recommended, prior to freezing.

Curing and Smoking: Following deboning, lamb sides were cured with a solution containing water, salt, sugar, sodium tripolyphosphate, sodium erythorbate, and sodium (standard ham

Figure 1. Experimental flow diagram for manufacturing Wisconsin Lamb Rolls.





curing brine). The boneless lamb sides and added brine (equal to 10% of boneless lamb weight) were tumbled for 6 cycles, each consisting of 15 minutes of rotation and 15 minutes of rest, at 40°F. Cured lamb sides were held in the tumbler for an additional 72 hours at 40°F to insure complete brine uptake and uniform distribution within the muscles. Cured lamb sides were then rolled, netted, weighed, and placed on horizontal racks for smoking and cooking.

D. Thermal Processing and Microbial Lethality of Lamb Rolls:

Cured and Smoked Lamb Rolls: The smokehouse schedule used for processing cured and smoked lamb rolls was described in Table 1 (**Study 1**). The cooking and smoking process was completed in 10 hours. Cooked products were cooled at 40°F overnight and then vacuum packaged and stored at the same temperature. As in **Study 1**, process lethality was calculated using internal temperatures obtained during cooking, and the integrated time/temperature lethality model (down loaded from the American Meat Institute web site (www.meatami.org)). Similar to **Study 1**, results revealed that this cooking procedure for cured and smoked product
was more then sufficient to provide a greater than 7 log reduction of *Salmonella, Listeria monocytogenes*, and *E. coli* 0157:H7, affirming the safety of this rolled product.

Fresh Lamb Rolls: Frozen control, Fibrimex-treated and Transglutaminase-treated lamb rolls were thawed and roasted in a conventional oven. Internal temperature was monitored by a thermocouple. Cooking was carried out as described in **Study 1**, 450°F for 30 minutes uncovered, and then at 300°F covered with aluminum foil to an internal temperature of 145°F. Internal temperature increased by 5°F after removal from oven.

The roasting procedure was completed in approximately 3 hours. After achieving the target temperature, product was allowed to cool at room temperature to 130°F internal prior to slicing. A DATAtrace probe was also inserted into one roll during cooking to collect internal temperature information for calculating the F-value, an indication of process lethality for destroying pathogenic bacteria which might be in the center of the roll. Results revealed that the cooking procedure employed was sufficient to provide greater than a 7 reduction of *Salmonella*, *Listeria monocytogenes*, and *E. coli* 0157:H7, confirming the safety of the roasting method used.

E. Cooking Yields of Lamb Rolls:

Cooking yields were calculated for all treatments (Table 3). In general, both Transglutaminase and Fibrimex treated rolls had higher cooking yields than control rolls, probably due to their more tightly bound physical structure providing better water holding during cooking. Water losses included drip (during thawing), juices and evaporated moisture (during cooking). Average total losses were 20.0% for control, 11.6 % for Transglutaminase-treated, and 10.2 % for Fibrimex-treated lamb rolls. Similarly, cured and smoked lamb rolls had a higher yield (9.2% water loss) than control rolls. Although no binding agent was used in the cured and smoked treatment, muscle proteins extracted by salt during tumbling act as a natural binding agent, resulting in increased water holding capability.

The cooking yields for like products in **Study 1** and **Study 2** were very similar. The respective observed yields for **Study 1** vs **Study 2** were: control rolls – 79.7 vs 80.0%; Fibrimex-treated rolls – 91.3 vs 89.8%; and cured and smoked rolls – 90.2 vs 90.8%. It should be noted that the cooking yields reported for the cured and smoked lamb rolls were based upon the starting weight of the cured product prior to cooking/smoking. Because that cured weight included approximately 10% brine pick up, and since the cooking loss was about 10%, the final processed weights of the cured and smoked lamb rolls were very similar to the starting weights of the raw, uncured meat (the finished cured/smoked lamb rolls weighed essentially the same as the starting raw meat before curing).

Despite the limited data, producing lamb rolls in combination with a binding strategy (natural or added) may produce a higher economic value, due to both higher cooking yield and improved texture and juiciness. This 10% difference in cooking yield among bound products means that if starting lamb rolls weighed 15 pounds, treated products would provide 1.5 more pounds of cooked product per roll to sell at the final retail price, than would control lamb rolls.

F. Evaluation of Lamb Rolls Through Sensory Panel Testing:

Fresh Lamb Rolls: It was clearly shown that using binding agents (Fibrimex and Transglutaminase) in lamb roll products resulted in a higher cooking yield than control (untreated) lamb rolls. Although this is an economically valid reason to use these agents, it must be assured that the acceptability of treated products will be the same as or better than control

Table 3. Summary of yields obtained during the manufacture and cooking of Wisconsin Lamb Rolls.

Boning Yield (average % ±%, n=14)[a]*:*

		inedible trim	
Boneless roll	Edible trim	Fat	Bone
55.3 ± 3.3	11.9 ± 2.7	11.8 ± 2.1	24.0 ± 2.5

Cooking Yield (average % (range in %), n=2)[a]*:*

	Cooking
Control	80.0 (80.2, 79.7)
TGase[b]	88.4 (87.1, 89.6)
Fibrimex[c]	89.8 (89.6, 90.1)
C&S[d]	90.8 (89.2, 92.5)

[a] Based on boneless lamb roll
[b] Lamb rolls treated with Transglutaminase
[c] Lamb rolls treated with Fibrimex
[d] Cured and smoked lamb roll

products. Therefore, the primary objective of this phase of **Study 2** was to compare the sensory characteristics of binding-agent treated rolls with control rolls. Two independent descriptive sensory analysis tests were conducted by trained panelists (31 and 34 on each day) at the Sensory Analysis Laboratory of the Department of Food Science, University of Wisconsin-Madison.

In each test one Fibrimex-treated, one Transglutaminase-treated and one untreated control lamb roll were compared. Following thawing at 40°F control, the lamb rolls were roasted at the Meat Science Laboratory according to the cooking method described earlier. The cooked rolls were then transferred to the Sensory Analysis Laboratory in thermo-insulated containers within 15 minutes of cooking, prior to slicing and serving to panelists. Panelists evaluated lamb rolls for visual appearance, texture and flavor, and overall acceptability (Attachments 7 and 8 are the sensory ballots used). The mean responses from both panels are summarized in Table 4A. Table 4B presents a narrative summary of the findings.

Results revealed that using either binding agent significantly changed the visual appearance and improved the visual appeal of lamb roll slices to panelists, probably due to their more intact appearance, having less fractures/seams within slices. Moreover, Fibrimex-treated lamb rolls were significantly more preferred than Transglutaminase-treated lamb rolls in visual appeal. There is a probable reason for this difference. The Fibrimex system binds together all types of surfaces, including lean surfaces to fat surfaces. However, Transglutaminase is an enzyme which can only function at protein-to-protein interfaces. So within the Transglutaminase-treated product wherever a lean (protein) surface contacted a fat surface within the lamb roll, poorer binding results. Overall, both the Fibrimex and Transglutaminase treatments greatly enhanced the intactness of lamb roll slices, with Fibrimex appearing to provide the most complete and thorough binding. Any Fibrimex advantage in binding must be weighed against its more complicated and time consuming application procedure.

Table 4A. Comparison of mean scores of descriptive sensory analysis of roasted lamb rolls.
(Panel 1 = 34 evaluators; Panel 2 = 31 evaluators).

	Control	Transglutaminase-treated	Fibrimex-treated
VISUAL APPERANCE ATTRIBUTES			
Degree of cooking doneness[1]			
Panel 1	4.87 A[10]	2.53 C	4.16 B
Panel 2	5.46 A	2.91 C	3.31 B
Integrity (Intactness) of slices of meat[2]			
Panel 1	2.39 A	4.95 B	4.68 B
Panel 2	2.71 A	3.55 B	4.92 C
Fractures/seams within slices of meat[3]			
Panel 1	5.21 A	2.83 C	3.85 B
Panel 2	4.68 A	4.31 A	3.49 B
Visual appeal[4]			
Panel 1	2.73 A	3.72 B	4.42 C
Panel 2	3.63 A	3.26 A	4.48 B

[1] Scale: 1= Undercooked, not done; 7= Overcooked, very done
[2] Scale: 1= Very fragmented, not intact; 7= Very intact
[3] Scale: 1= Limited seams between meat sections; 7= Abundant seams between meat sections
[4] Scale: 1= Very unappealing; 7= Very appealing
[10] Mean scores in the same row bearing the same letter are not significantly different at the 5% level.

Table 4A (continued). Comparison of mean scores of descriptive sensory analysis of roasted lamb rolls. (Panel 1 = 34 evaluators; Panel 2 = 31 evaluators).

	Control	Transglutaminase-treated	Fibrimex-treated
FLAVOR AND TEXTURE ATTRIBUTES			
Juiciness[5]			
Panel 1	3.50 A[10]	4.64 B	4.53 B
Panel 2	3.46 A	4.70 B	4.25 B
Tenderness[6]			
Panel 1	4.08 A	4.52 AB	4.87 B
Panel 2	4.44 A	4.71 A	4.18 A
Lamb flavor intensity[7]			
Panel 1	3.82 A	3.88 A	3.42 A
Panel 2	3.38 A	3.77 A	3.53 A
Off-flavor intensity[8]			
Panel 1	2.96 A	2.92 A	3.15 A
Panel 2	2.62 A	2.83 A	2.88 A
Degree of cooking doneness[1]			
Panel 1	4.74 A	4.03 B	3.66 B
Panel 2	4.72 A	3.89 B	3.95 B
OVERALL ACCEPTABILITY[9]			
Panel 1	3.92 A	4.40 A	4.21 A
Panel 2	4.55 A	4.12 A	4.24 A

[1] Scale: 1= Undercooked, not done; 7= Overcooked, very done
[5] Scale: 1= Not juicy; 7= Very juicy
[6] Scale: 1= Not tender, tough; 7= Very tender
[7] Scale: 1= Mild, lamb-like; 7= Strong, mutton-like
[8] Scale: 1= Absent; 7= Very strong, pronounced
[9] Scale: 1= Extremely unacceptable; 7= Extremely acceptable
[10] Mean scores in the same row bearing the same letter are not significantly different at the 5% level.

Table 4B. Narrative summary of descriptive sensory analysis of roasted lamb rolls. (Panels 1 and 2).

	Control	Transglutaminase-treated	Fibrimex-treated
VISUAL APPERANCE ATTRIBUTES			
Degree of cooking doneness	most intermediate doneness	least done	in done
Integrity (Intactness) of slices of meat	less intact	more intact	much more intact
Fractures/seams within slices of meat	more fractures	less fractures	less fractures
Visual appeal	less appeal	more appeal	most appeal
FLAVOR AND TEXTURE ATTRIBUTES			
Juiciness	less juicy	more juicy	more juicy
Tenderness	ND[1]	ND	ND
Lamb flavor intensity	ND	ND	ND
Off-flavor intensity	ND	ND	ND
Degree of cooking doneness	more done	less done	less done
OVERALL ACCEPTABILITY	ND	ND	ND

[1] ND = no significant difference

Juiciness of both treated lamb rolls (Fibrimex and Transglutaminase) was significantly better than control lamb rolls (Tables 4A/4B). While possible inherent variation in juiciness and tenderness among individual animal carcasses might exist, the differences observed in these tests are more likely explained by less water loss during cooking in treated lamb rolls compared to control lamb rolls. Also, using binding agents did not cause a significant difference in lamb flavor intensity or off-flavor intensity among the rolls. Panelists rated all lamb rolls similar in overall acceptability. However, with higher cooking yields, improved slice intactness and better juiciness, use of either binding agents could increase the perceived value of the Wisconsin Lamb Roll to end users.

In both panels evaluators perceived the treated rolls to have a lesser degree of doneness than control rolls, although all should have been cooked to the same approximate internal temperature. This suggests that better binding/trapping of moisture by treated rolls during cooking may also affect visual degree of doneness.

Cured and Smoked Lamb Rolls: In two separate sensory tests, cured and smoked lamb roll (C&S) was compared with a premium boneless pork ham (Cure 81, Hormel Foods) to determine the potential acceptability of C&S lamb roll as an alternative cured product. Both C&S lamb roll and pork ham were reheated before slicing and serving to panelists. Results for both panels are summarized in Tables 5A and 5B.

Panelists significantly preferred the visual appearance of the pork ham. They rated slices of the C&S lamb roll as being significantly darker in color, less uniform in color, having more fractures/seams and more abundant in fat. The comparative Cure 81 ham is an extremely lean, tightly bound product, so the differences observed were not unexpected.

Among flavor and texture attributes, there was no significant difference in overall acceptability between pork ham and C&S lamb roll. Panelists rated the products similar in firmness, tenderness, cured/smoked flavor intensity, salt flavor intensity and off-flavor intensity. The only

significant difference among the attributes tested was for lamb flavor intensity where, as expected, the C&S lamb roll had a stronger lamb flavor.

Table 5A. Comparison of mean scores of descriptive sensory analysis of cured and smoked lamb roll and boneless ham. (Panels 3 and 4 each had 31 evaluators).

	Cured and Smoked Lamb roll	Boneless ham
VISUAL APPERANCE ATTRIBUTES		
Overall color properties[1]		
Panel 3	5.11 A[13]	3.05 B
Panel 4	5.07 A	3.17 B
Uniformity of color within slices of meat[2]		
Panel 3	3.25 A	3.70 A
Panel 4	3.02 A	4.68 B
Fractures/seams within slices of meat[3]		
Panel 3	4.93 A	2.40 B
Panel 4	4.94 A	2.55 B
Relative Abundance of fat[4]		
Panel 3	4.62 A	2.76 B
Panel 4	4.27 A	2.69 B
Visual appeal[5]		
Panel 3	3.49 A	4.37 B
Panel 4	3.68 A	4.68 B

[1] Scale: 1= Light, pale pink; 7= Dark, purplish pink
[2] Scale: 1= Not uniform; 7= Very uniform
[3] Scale: 1= Limited seams between meat sections; 7= Abundant seams between meat sections
[4] Scale: 1= absent; 7= abundant
[5] Scale: 1= Very unappealing 7= Very appealing
[13] Mean scores in the same row bearing the same letter are not significantly different at the 5% level.

Table 5A (continued). Comparison of mean scores of descriptive sensory analysis of cured and smoked lamb roll and boneless ham. (Panels 3 and 4 each had 31 evaluators).

	Cured and Smoked Lamb roll	Boneless ham
FLAVOR AND TEXTURE ATTRIBUTES		
Firmness[6]		
Panel 3	4.28 A[13]	4.23 A
Panel 4	3.91 A	4.51 B
Tenderness[7]		
Panel 3	4.38 A	4.48 A
Panel 4	4.59 A	4.37 A
Lamb flavor intensity[8]		
Panel 3	3.23 A	2.54 B
Panel 4	3.96 A	2.28 B
Overall cured and smoked flavor intensity[9]		
Panel 3	3.89 A	4.38 A
Panel 4	3.75 A	4.14 A
Salt flavor intensity[10]		
Panel 3	4.07 A	4.09 A
Panel 4	3.63 A	3.90 A
Off-flavor intensity[11]		
Panel 3	2.69 A	2.29 A
Panel 4	2.48 A	2.18 A
OVERALL ACCEPTABILITY[12]		
Panel 3	4.52 A	4.86 A
Panel 4	4.54 A	5.00 A

[6] Scale: 1= Very soft; 7= Very firm
[7] Scale: 1= Not tender, tough; 7= Very tender
[8] Scale: 1= None; 7= Strong, mutton-like
[9] Scale: 1= Absent; 7= strong
[10] Scale: 1= Very weak; 7= Very strong
[11] Scale: 1= Absent; 7= Very strong, pronounced
[12] Scale: 1= Extremely unacceptable; 7= Extremely acceptable
[13] Mean scores in the same row bearing the same letter are not significantly different at the 5% level.

Table 5B. Narrative summary of descriptive sensory analysis of cured and smoked lamb roll and boneless ham. (Panels 3 and 4).

	Cured and Smoked Lamb roll	Boneless ham
VISUAL APPERANCE ATTRIBUTES		
Overall color properties	darker color	lighter color
Uniformity of color within slices of meat	uniform	slightly more uniform
Fractures/seams within slices of meat	more fractures	much less fractures
Relative Abundance of fat	more fat	much less fat
Visual appeal appealing	less appealing	more
FLAVOR AND TEXTURE ATTRIBUTES		
Firmness	firm	slightly firmer
Tenderness	ND[1]	ND
Lamb flavor intensity	more lamb flavor	less lamb flavor
Overall cured and smoked flavor intensity	ND	ND
Salt flavor intensity	ND	ND
Off-flavor intensity	ND	ND
OVERALL ACCEPTABILITY	ND	ND

[1]ND = No significant difference

It is very encouraging that the panelists rated the overall acceptability of the C&S lamb roll comparable to a premium pork ham. We personally thought the C&S lamb roll was a very good product, having acceptable bind (slice intactness), strong cured color and a desireable cured meat flavor. We thought the flavor of the C&S lamb roll was not that much different than the pork ham flavor, particularly when tasted cold. We observed that some people had difficulty distinguishing between the cured lamb and pork products.

This data suggest that cured and smoked lamb roll might be considered as an alternative lamb roll product and may have a marketing potential among consumers, especially among ethnic groups who do not normally consume ham (pork), such as Muslim and Jewish consumers. The New Zealand meat scientists, Locker, reported on experiments with "cured lamb" in a chapter in **Developments in Meat Science 1** (1980. R. Lawrie (ed). Applied Science Publishers, Ltd., London). He too regarded cured, cooked lamb legs to be a very good product. Locker recorded the following comments on sensory panel response to cured lamb legs (from lamb on three different feeding regimes) and traditional pork ham: "The panels could not distinguish between the different feed regimes in the legs cured as 'ham'. They could, however, distinguish all of the 'lamb hams' from real ham ($p < 0.05$). They showed no significant preference for any of the three 'lamb hams' or real ham. 'Waxy fat' was a common criticism of all the lamb hams. Most tasters felt that while the lamb ham was similar to the real ham it was very good in its own right, and that comparison with the real thing was perhaps unfair."

The curing and smoking of lamb rolls or other lamb carcass parts is not very novel or difficult to do. It is not known why cured and smoked lamb products have not achieved greater prominence in the lamb industry. Is it because marketing of such products has not been tried in a tradition-bound industry, or is there some element of consumer resistance toward this product? We feel this product deserves additional attention, in an industry seeking new product innovation, and in a nation with an increasing population of diverse cultures open to and favoring lamb products.

IV. Other Subjective Evaluations of Wisconsin Lamb Rolls

A. Lamb Industry Veteran – Bill Blake:

Bill Blake has been associated with the U.S. lamb industry for over 30 years, training processors and retailers in merchandising and marketing methods, and promoting lamb products to many audiences. We invited Bill to join us for the fabrication part of **Study 2**, to observe the process and product, and to assist in the preparation of the rolls. Below are Bill's paraphrased comments with respect to the product:

1. The major obstacle with this product is developing consistency and uniformity. There are several factors which can contribute to a lack of conformity in the lamb roll:

    - lambs can differ markedly in their composition, especially as it relates to fat content and size of carcass. To produce a successful, uniform product the lambs should be produced under tight specifications, which might include breed and management system, but would certainly include size (weight) and finish (fat cover).
    - preparing the lamb roll takes a definite amount of skill. Anyone can cut loin chops which are similar in thickness and fat trim, but the level of skill of the butcher will undoubtedly produce variation in the properties of lamb rolls. Since all of us differ in our skill level and how we interpret instructions, this source of variation may not be absolutely overcome. But developing specific fabrication instructions and investing in training for processors holds hope for minimizing the variation do to this "people" factor.
    - an inherent factor affecting variation in the composition of a lamb roll is the fact that the product encompasses the whole lamb carcass, consisting of different parts which vary significantly in their properties. The leg half consists of a small number of large muscles, with a minimum of seam fat. The shoulder end contains a larger number of small muscles, with a substantial amount of seam fat. Lean lambs and close trimming would tend to minimize this difference. Fat lambs and marginal trimming would tend to

accentuate this difference in appearance and fat contend of the cooked product. The relative importance of this variation is yet to be fully tested in food service operations. However, if two people in a group both order lamb roll, and one's portion is lean and meaty, and the other's has a large amount of seam fat, it probably will be point of contention. Perhaps lamb rolls could be marketed as leg-end or shoulder-end "half rolls," so that all products from the same roll half would be fairly uniform.

2. Who is the customer for this product? It is really too big for retail. It's major promise would seem to be with food service. Another potential major market could be ethnic groups (particularly Middle East) who have restrictions on what foods they can eat, and usually lamb is a major staple in their diet. The lamb roll would provide a large size product which might fit into large gatherings, and food service operations, which cater to such ethnic groups.

3. The cured and smoked lamb roll seems to be a good idea. It has very good eating properties, improved shelf stability and offers a "ham-like" alternative to people who cannot eat ham or other cured pork products. Unfortunately, history has said that "it won't fly." How could such a product be marketed to attract the attention of the potential customers and take advantage of this product's desirable properties?

4. As with most lamb products, they are more expensive than most meats. This is a general deterrent in the marketing of lamb.

This is a good product, but it does require attention to the details described above. Bill believes that the ideal lamb carcass to make desirable Wisconsin Lamb Rolls would be yield grade 1 or 2 (fairly lean), and weigh less than 50 pounds.

B. Chef Paul Short and His Culinary Art Class:

Since it appears likely that the major market for the Wisconsin Lamb Roll might be in food service, we thought it important to get a reaction from chefs who would be using the

product. To accomplish this we took partially-cooked control lamb roll, Fibrimex-bound lamb roll and cured and smoked lamb roll to Chef Paul Short's Culinary Arts Class at Madison Area Technical College. We finished cooking the rolls to the desired degree of doneness at the school while we explained the product and process to the class.
Class members felt it important to explain the nature of the binding agents used to consumers, and wondered if it would be an issue for them. The group commented that lamb rolls had a mellow flavor (not overly strong lamb flavor). They felt it was moist and tender, and particularly liked the browned surface flavor. They could see using it at a carving station in a buffet line.
They felt the biggest concern was the lack of uniformity from one end to another. The shoulder end had much more seam fat, and while that may contribute to juiciness and flavor of the cooked product, they thought some people would find it objectionable. They also wondered about differences in tenderness among muscles.

They could not detect a flavor difference between the regular and bound lamb rolls. They thought the cured and smoked roll was a very good product too, and a few commented that when tasted in the cold state, it was indistinguishable from pork ham.

Overall, Chef Short and his class thought the product had promise in the food service industry. Their biggest concern was the variability in fat content and muscle type along its length. This reoccurring concern points out the need to select lambs which will have a smaller amount of seam fat, and to do a rigorous job of trimming as the lamb roll is prepared.

C. Staff and Students of the Meat Science Laboratory/Animal Sciences Department:

Product left over from Chef Paul Short's class evaluation was prepared for an advertised lunch in the conference room of the Meat Science Laboratory. Thirteen individuals showed up, including our department's sheep specialist, Dave Thomas, and a visiting Spanish animal scientist who specialized in dairy sheep. The rest of the guests were faculty, graduate students and support staff. We attempted to gather as much information

from these individuals about their impression of a Fibrimex-bound lamb roll, and a cured and smoked lamb roll.

The following response was obtained to the question of how often members of this group they ate lamb:

6 = never

6 = occasionally

1 = often

Overall the guests seemed quite impressed with the lamb rolls, and the concept of producing them. After they tasted some of each, we asked them to state how they felt about each product, and received the following response:

	Number of Tasters	
	Fibrimex Lamb Roll	Cured/Smoked Lamb Roll
Excellent	3	3
Very good	5	8
OK	5	2
Slightly undesirable	--------	-------
Do not like	-------	-------

For a group of people who ate little or no lamb, the responses seemed quite positive. The responses suggested a very slight preference for the cured and smoked lamb roll over the regular cooked roll.

Our last question was: "which roll do you most prefer?" Their response was:

Number Preferring	
Fibrimex Lamb Roll	Cured and Smoked Lamb Roll
6	7

With this format the preference was almost equally split (very slight edge to the cured and smoked). The response from this group demonstrated both types of products were

highly acceptable, as judged by people who were for the most part not big lamb consumers.

D. Lamb Production Class at UW-Madison:

Professor Dave Thomas' spring Lamb Production Class traditionally ends with a lamb lunch at the end of the semester. In 2000, one of the products he served was a Wisconsin Lamb roll. A memo from Professor Thomas (Attachment 11) provides his class members' subjective evaluation of the Wisconsin Lamb Roll.

In general, the students rated the roll very positively for juiciness and texture (using Professor Thomas' evaluation system), but only average for flavor. The students also ate lamb chops at this session, and overall, 7 of 9 students preferred the chops over the lamb roll. This is not too surprising since chops are derived from one of the highest quality muscles in the carcass, while the lamb roll encompasses almost all muscles within the carcass.

Professor Thomas noted that several farm crew members joined the session at the end, and "raved about the roll."

V. Nutrient Content of Wisconsin Lamb Roll

The nutrient content of food is important to many consumers. Nutritional labels are required on all processed meat and poultry if annual production of an individual product exceeds 100,000 pounds per year. At this point in time nutritional labeling of fresh meat and poultry products (steaks, roasts, ground meats, etc.) has been optional. However, in 2001 the USDA published a regulatory proposal which would require the nutritional labeling of all fresh meat products. That proposal is still under consideration at this time. Whether to provide general information to consumers about the Wisconsin Lamb Roll, or to meet possible future nutritional labeling requirements, it was important that the nutrient composition of this product be investigated.

A. Methods:

Three lamb rolls were cooked submitted to Covance Laboratories in Madison, Wisconsin for determination moisture, protein, total fat, cholesterol and iron. A single lamb roll (C-1 from **Study 1**) submitted in October, 1999, was cooked to a medium-rare degree of doneness (145-150°F internal). Two lamb rolls (C-2 and C-3 from **Study 2**), submitted in June, 2000, were inadvertently cooked to a very well done degree (>170°F). Each cooked lamb roll was allowed to cool for approximately 15 minutes, then sliced into one inch slices. Trimmable fat was removed from the slices as would be done by a typical consumer. The remaining trimmed lean was vacuum packaged and chilled, and delivered to Covance Laboratories for analysis. Covance ground and blended all pieces from each lamb roll to achieve a homogenous mixture, which was then sampled for analyses. Duplicate determinations were performed for moisture, protein and fat on the first lamb roll to check the level of homogeneity achieved in the blending process. The very similar results obtained for protein (21.3% and 21.0%), moisture (62.3% and 62.6%) and fat (16.9% and 16.2%) confirmed that Covance=s blending process did indeed provide a homogenous sample, allowing the cost saving of only running single determinations on the other two lamb rolls.

B. Results:

Table 6 presents the results of analyses on the three Wisconsin lamb rolls submitted to Covance. Results are based upon 100 grams of product, the form in which the data was received from Covance. It is quite obvious that the nutrient content of the lamb roll cooked to the medium rare degree of doneness (C-1) was substantially different from the values for the lamb rolls cooked to very well done (C-2 and C-3). As cooking continues to a higher degree of doneness, more water is lost from the product concentrating the protein, cholesterol and iron, which are less able to leave the product during cooking. However, the fat content went down with increased cooking, owing to further melting of fat with increasing product temperature, allowing more fat migration out of the product, into the drippings.

So we really had two different types of samples B one sample cooked to medium rare, and two samples cooked to very well done. To simply average all three together would

have biased the result toward the more done samples. Experiences with the lamb roll have shown that the medium rare to medium degree of doneness provide for a more juicy and tender product, which will be preferred by consumers.

Following this line of reasoning, it was decided that to get the most accurate Aaverage@ nutrient content for a cooked lamb roll from our results, the values for the two well done products should be first averaged together, and then that single value should be combined with the result from the medium-rare product to produce a final average. This should provide values approximating a lamb roll cooked to the medium B medium-well range of doneness.

Lines (1), (2) and (3) in Table 6 provide the nutrient results for the three individual lamb rolls. Line (4) provides the mean nutrient content of the two well-done lamb rolls. Line (5) gives the mean values of the medium-rare lamb roll (Line 1) and the average of the two well-done lamb rolls (Line 4). The values in line (5) provide the best current estimate of the nutrient content of the Wisconsin Lamb Roll.

Table 7 provides a comparison of the Wisconsin Lamb Roll to other lamb products, as listed in the USDA=s Nutrient Database for Standard Reference, the definitive source for nutrient information for all foods consumed in the U.S. (http://www.nal.usda.gov/fnic/foodcomp/). All products in this table are expressed on the basis of 3 ounce (85 gram) cooked, trimmed servings, which is the standard serving size designated for cooked fresh meat and poultry products. Three ounces of meat is the size of a quarter-pound hamburger (4 ounces raw = 3 ounces cooked), or a standard size deck of playing cards.

The determined protein content of the lamb roll was only slightly lower than that of most other lamb products. All meat and poultry products are an excellent source of high quality protein, with one three ounce serving providing almost half of a person=s daily needs.

The lamb roll was slightly higher in total fat than most other lamb cuts. This can be explained by the fact that the other products were cooked as individual cuts by broiling or roasting, so that as the trimmable fat melts, it can migrate away from the product. However, in the case of the lamb roll, much of this fat is confined within the roll, where it can be absorbed more easily into the lean. So even though the lamb roll slices were trimmed of removable fat in the manner of a careful consumer, some melted fat was already absorbed by the adjacent lean.

It should be noted that the fat content of the lamb roll can be significantly affected by the degree of finish on the lamb, and the extent of fat trimming during lamb roll preparation. We believe that superior lamb rolls could be produced from lighter weight lambs which naturally provide a lower fat content in the finished product (and a saving on trimming time during fabrication), as well as a probably preferable lighter weight final product. In both production runs in this project, the animals utilized were a little heavier and a little fatter than we preferred. Although we attempted to be very rigorous in fat trimming during fabrication, it is not possible to completely remove excess fat from overly fat lambs by trimming alone.

Table 7 also provides the grams of saturated fat in the lamb cuts. We did not determine the fatty acid content of the lamb rolls because of the extremely high cost of that analysis, and because the fatty acid content of fat is fairly constant within a species. In this table the saturated fat content of the lamb rolls was estimated by multiplying the total fat content by the expected proportion of saturated fatty acids in lamb fat (0.36). The saturated fat content of foods is provided in nutrient information because large amounts of saturated fat in the diet can elevate the serum cholesterol of some individuals. Serum cholesterol is a risk factor in cardiovascular disease. Like most meat and poultry products, one to two servings fit very well into a heart healthy diet, which recommends for a 2000 calorie daily diet, limiting fat consumption to less than 65 grams (two servings of lamb roll provide 26 grams), and saturated fat to less than 20 grams (two servings of lamb roll provide about 10 grams).

The cholesterol content of lamb rolls is similar to values for other lamb cuts (and most other red meat and poultry products). Likewise, the iron content of the lamb rolls is not substantially different from other lamb cuts. Red meat is an excellent source of iron (required for blood cell formation), not only because it is present in meat in relatively large amounts, but also because the iron from meat is better absorbed and utilized by the body than iron from plant sources.

For information and comparison purposes Table 8 provides the nutrient content of 3 ounce servings of other meat and poultry products consumed in the American diet, and the perspective of daily dietary recommendations for each nutrient.

Table 6. Nutrient Composition of Cooked Wisconsin Lamb Rolls.

Wisconsin Lamb Roll Results:						
100 Grams (3.5 ounces) - Cooked						
	Protein (gm)	**Moisture (gm)**	**Total Fat (gm)**	**Cholesterol (mg)**	**Iron (mg)**	**Calories**
(1) C-1 Med Rare	21.2	62.5	16.6	76	1.3	234
(2) C-2 Very Well	31.8	53.0	14.8	117	2.2	269
(3) C-3 Very Well	28.7	55.5	14.7	120	1.6	256
(4) Mean of C-2/C-3	30.3	54.3	14.8	119	1.9	263
(5) Mean of (1) and (4)	25.8	58.4	15.7	98	1.6	249

gm = grams; mg = milligrams; mcg = micrograms

Table 7. Comparison of the Nutrient Composition of Wisconsin Lamb Roll to Other Lamb Cuts.

All Lamb Products:							
3 Ounces (85 grams) Serving - Cooked, Trimmed							
Product	**Protein (gm)**	**Moisture (gm)**	**Total Fat (gm)**	**Saturated Fat (gm)**	**Cholesterol (mg)**	**Iron (mg)**	**Calories**
Lamb roll (roasted)	21.9	49.6	13.3	4.8	83	1.5	212
Leg (roasted)	24.1	54.3	6.6	2.4	76	1.8	162
Loin (broiled)	25.5	51.8	8.3	3.0	80	1.7	183
Rib (broiled)	23.6	50.0	11.0	4.0	77	1.9	200
Arm chop (broiled)	23.6	52.9	9.0	2.9	78	2.0	170
Blade chop (broiled)	21.6	53.1	9.6	3.4	77	1.5	179

Table 8. Comparison of the Nutrient Composition of Various Meat and Poultry Products.

Other Meat Products:

3 Ounces (85 grams Serving) - Cooked, Trimmed/Skinless Lean

Product	Calories	Protein (gm)	Total Fat (gm)	Saturated Fat (gm)	Cholesterol (mg)	Iron (mg)
Daily Dietary Recommendations (based upon 2000 calorie diet)	2000	50	<65	<20	<300	8 - M 18 - F
Beef[3]						
Round	161	27	5.0	1.7	71	2.4
Loin	182	29	8.6	3.3	65	2.1
Pork[3]						
Leg (fresh)	179	25	8.0	2.8	80	1.0
Loin	173	26	6.6	2.3	68	0.7
Lamb[3]						
Leg	162	24	6.6	2.4	76	1.8
Loin	183	25	8.3	3.0	80	1.7
Veal[3]						
Leg	128	24	2.9	1.0	88	0.8
Loin	149	26	5.9	2.2	90	0.7
Chicken[3]						
Breast	140	26	3.0	0.9	72	0.9
Thigh	178	22	9.2	2.6	81	1.1
Turkey[3]						
Breast	115	26	0.6	0.2	71	1.3
Dark meat	138	25	3.7	1.2	95	2.0

gm = grams; mg = milligrams; mcg = micrograms; M = males; F = females

[1]Source: USDA Nutrient Database for Standard Reference.

VI. Cost Analysis of Wisconsin Lamb Roll

Using yield data obtained in these studies and current processing plant charges, cost per pound of boneless lamb roll, based on 100 lb. live weight lamb, was calculated as follows:

$/lb of boneless lamb roll = Total costs – $ value of edible trim
Weight of boneless lamb roll (lbs.)

A. Estimated Costs (based upon 1 lamb):

- Live animal, 100 lbs., @ $0.80 per lb. $80.00
- Slaughter charges $25.00
- Processing/fabrication cost (50 lbs. @ $0.40 per lb.) $20.00

Total costs ……..**$125.00**

B. Estimated Value of Edible Trim:

Edible trim includes shanks and lean trim, and composes approximately 12% of chilled lamb carcass wt.. This trim could be sold for approximately $1.50 per pound.

- Live weight: 100 lb
- Hot carcass yield (50%): 50 lb
- Chilled carcass yield (97% of hot carcass weight): 48.5 lb
- Edible trim (12 % of chilled carcass weight): 5.8 lb

Predicted economical value (5.8 X $1.50) $8.70

C. Estimated Cost Per Pound of Boneless Lamb Roll:

Average yield of boneless lamb roll was 55% of chilled carcass weight. Therefore, expected total boneless lamb roll weight from a 48.5 lb. carcass is 26.6 lbs. (13.3 lbs. per lamb roll).

Cost ($/lb) of boneless lamb roll = $125.00 – $8.70
26.6 lbs.

= $4.37/lb.

D. Effect of Fibrimex or Transglutaminase Treatment on Lamb Roll Cost:

If Fibrimex is used, $0.15 per pound should be added to the cost (about $2.00 per lamb roll). Estimated cost per pound will be $4.52.

If Transglutaminase is used, $0.20 per pound should be added to the cost (about $2.75 per lamb roll). Estimated cost per pound will be $4.57.

E. Potential Profit Chart:

The above prices are estimated "break-even" selling price for lamb rolls, if credit for the live lamb was set at $0.80 per pound. This does not take into account any transportation costs for the live lamb, or marketing costs to promote, sell and deliver the rolls. The table below projects added profit which the system might attain if the rolls could be sold at various prices above the estimated break-even prices.

	Added Profit per lamb ($) from 2 rolls		
Lamb Roll Selling Price ($/lb)	Untreated ($4.37/lb.)	Fibrimex-Treated ($4.52/lb.)	Transglutaminase-Treated ($4.57/lb.)
5.00	16	12	11
5.50	30	26	24
6.00	43	39	38
6.50	56	52	51
7.00	70	66	64
7.50	83	79	78

VII. Summary and Discussion

Work done by Sandy and Patrick Russell in conjunction with their first ADD grant verified the

potential of the Wisconsin Lamb Roll as a new, value-added lamb product which could benefit the lamb industry and improve returns to producers. In this work done in

connection with the second ADD grant processing procedures, fabrication yields, food safety concerns, product evaluations and nutrient composition have been addressed.

The Wisconsin Lamb Roll adds value to the lamb carcass by providing a convenient product which is boneless, trimmed of most waste fat, uniform in shape, and larger in size than any traditional lamb products. Finished lamb rolls make up about 55% of a chilled lamb carcass weight, with an accompanying yield of about 12% edible trim.

After cooking, slices of the original version of the Wisconsin Lamb Roll tend to separate into several individual pieces during serving. This work demonstrated that treatment of lamb rolls with Fibrimex or Transglutaminase during fabrication greatly improved the "bind" (ability of individual muscles to adhere together) in sliced products. This not only improved the visual appearance as judged by sensory panel evaluators and culinary arts students, but also provided a 10% greater cooked product yield (a substantial economic advantage). The sensory panel rated cooked lamb rolls treated with these binding agents to be more juicy, and found control and treated products to be similar in overall acceptability. Although the use of Fibrimex and Transglutaminase may increase the cost of lamb rolls by 15 to 20 cents per pound, their use greatly improves intactness of slices and improves product juiciness, without changing flavor or tenderness.

Applying the curing and smoking process to lamb rolls provided an appealing variation in this product, providing a strong cured (red) lean color, salt-enhanced and smoked flavor, strong bind within slices and extended fresh (non-frozen) shelf life. While sensory panel members could generally distinguish between the flavor of cured and smoked lamb roll and cured and smoked ham (pork), they rated the overall acceptability of the two products to be the same. It is not that cured and smoked lamb roll need necessarily be compared to ham, for the lamb product is very desirable in its own right. Compared to the beef, pork and turkey industries, the lamb sector has few cured and smoked products to offer consumers. Judged by the perceived quality of the cured and smoked lamb rolls produced in this project (and described by New Zealand workers in previous studies), it is surprising that production of cured and smoked lamb products (including possibly cured

and smoked legs and shoulders) hasn't been more rigorously pursued in the U.S., or in other parts of the world. For the many ethnic groups within our country who shun pork consumption for religious or cultural reasons, these would offer to them products similar in characteristics to cured pork items. It is likely that tradition is the main stumbling block to the marketing of such cured and smoked lamb products.

Product safety is always the highest priority in the production of any food. Fecal pathogens such as *Salmonella* and *E. coli* 0157:H7 can occasionally contaminate carcasses during the slaughter process. While intact muscle is virtually free of bacteria, the boning and rolling process applied to lamb rolls introduces the possibility that pathogens could find their way into the interior of the product. It is therefore essential that heat treatments applied to the products prior to consumption be adequate to destroy any pathogens potentially contaminating the center of the roll. In these studies, during both oven roasting of fresh lamb rolls, and cooking and smoking of cured products, time/temperature information was gathered at the center of the rolls. Utilizing this data to perform thermal death time calculations, it was demonstrated that both cooking methods provide a more than adequate heat treatment to the center of the rolls to inactivate probable levels of pathogens which might contaminate the interior.

One of the most important considerations about the Wisconsin Lamb Roll is the variation in composition between the leg-end (few muscles, little seam fat) and the shoulder-end (many muscles, more seam fat). This variation can probably never be entirely eliminated, because of the natural muscle pattern within the lamb carcass. However, we believe it can be minimized, if the process begins with the proper lamb carcass and if the fabrication process pays close attention to fat trimming. Lighter weight, leaner lambs (90 to 100 pounds) may offer an advantage to minimize end-to-end variation in composition. The lambs used in our studies tended to be somewhat larger and fatter than we would have preferred. If excess external finish and seam fat are present in lamb carcasses, than even close trimming may not be able to resolve the composition differences satisfactorily between the two ends of the roll. Although seam fat will undoubtedly enhance juiciness and flavor within the product, it certainly can be an issue to potential users if present in

large amounts, and particularly when shoulder-end cuts are compared to leg-end slices. If this variation between the two ends cannot be resolved sufficiently to satisfy end-users, a possible alternative might be to market the two half rolls separately, thereby at least enhancing uniformity of the product within the half roll populations.

Nutrient composition was determined on 3 lamb rolls. Cooked Wisconsin Lamb Roll is generally similar in composition to most lamb cuts. On average, trimmed slices contained slightly more total fat than major lamb cuts, probably because fat deposits are trapped within the roll, and melted fat from them can migrate to and be absorbed by lean tissue. This is in contrast to the cooking of most lamb cuts where melted fat can flow away from the cut during cooking. All nutrient determinations were conducted on control (unbound) lamb rolls. Since the treated lamb rolls had about a 10% higher cooking yield, they would retain more moisture, and consequently have lower percentages of fat and other constituents. The type of lamb used and the trimming methods applied in the production of lamb rolls would undoubtedly have the largest influence on the nutrient composition of the Wisconsin Lamb Roll, particularly in regard to its fat content.

What is the future of the Wisconsin Lamb Roll? The development and evaluation work associated with the two ADD grants have demonstrated the viability and potential of this product, and exposed its challenges. The processing procedure has been defined, and product options explored. In our opinion there are four elements which must come together in order to fully pilot test this product, and prepare it for full production and distribution. These elements are:

1. A processing plant which believes in this concept, and is dedicated to producing high quality lamb rolls. This is a challenge, since most small plants in the state capable of manufacturing lamb rolls are already fully engaged in other enterprises. It may be necessary for a group of producers or some other entity to lease or purchase a suitable facility, and bring together the processing expertise to accomplish this. This, of course, is no small undertaking. It is highly desirable that

this plant be USDA inspected, so that its products could be marketed across state lines. In addition to Wisconsin's own lamb consuming population, the large cities of Chicago and Minneapolis are very close to our borders, and would greatly expand the potential market for the Wisconsin Lamb Roll.

2. A lamb producer, or more probably a group of producers, who have a strong interest in this product, and can provide a sufficient and continuing supply of lambs which meet the required specifications to produce high quality lamb rolls (light weight lambs with appropriate minimum fat cover).

3. An individual or organization with marketing expertise, that has a passion for this product, and will actively promote the Wisconsin Lamb Roll and seek out potential customers for it.

4. A broad base of customers to use the Wisconsin Lamb Roll and provide continuing feedback on it. Acquiring and supplying those customers will be the responsibility of the first three elements above. The most obvious customers are food service operators (probably "white table cloth" restaurants) and organizations who cater to groups. Little attention has been given thus far to marketing the Wisconsin Lamb Roll (or some variation of it) at retail. This is currently a secondary consideration in the marketing of this product, but at some point in time attention should be directed at how this lamb roll product might fit into the enormous retail market.

Nestled within the food service and retail markets are the consumer segments – traditional U.S. lamb consumers, and growing ethnic groups which favor lamb consumption. A concerted effort should be made to promote the use of the lamb roll with these diverse cultural communities. It is a hope that in the long run the Wisconsin Lamb Roll might play a part in moving more of the total U.S. population to make more purchase decisions for lamb.

ATTACHMENT 1

The Wisconsin Lamb Roll

HALF LAMB
Boned, closely trimmed, rolled and tied

A new dimension in lamb

We roll the entire leg, loin and shoulder into one boneless roast. Everything you buy goes on the table.

- Rotisserie
- Oven roast
- Stuffed
- Cut into steaks for grilling
- At the carving station for a buffet

Packaged in light (9–11 lbs.), medium (11–14 lbs.) and heavy (14–16 lbs.) sizes. The lamb used in the Wisconsin Lamb Roll is locally grown and fabricated to the high standards you expect of Wisconsin products.

TRIMMED ...
so you don't have to.

BONELESS ...
so there's no waste.

LEAN ...
so everything you buy is healthful.

The Wisconsin Lamb Roll

Everything rolled into one ...

CONVENIENCE • QUALITY • VALUE • VERSATILITY

To order or for more information, contact:
Patrick J. Russell • THE WISCONSIN LAMB ROLL
18256 County NN • Cazenovia, Wisconsin 53924 • Phone and fax (608) 647-7351

Attachment 2

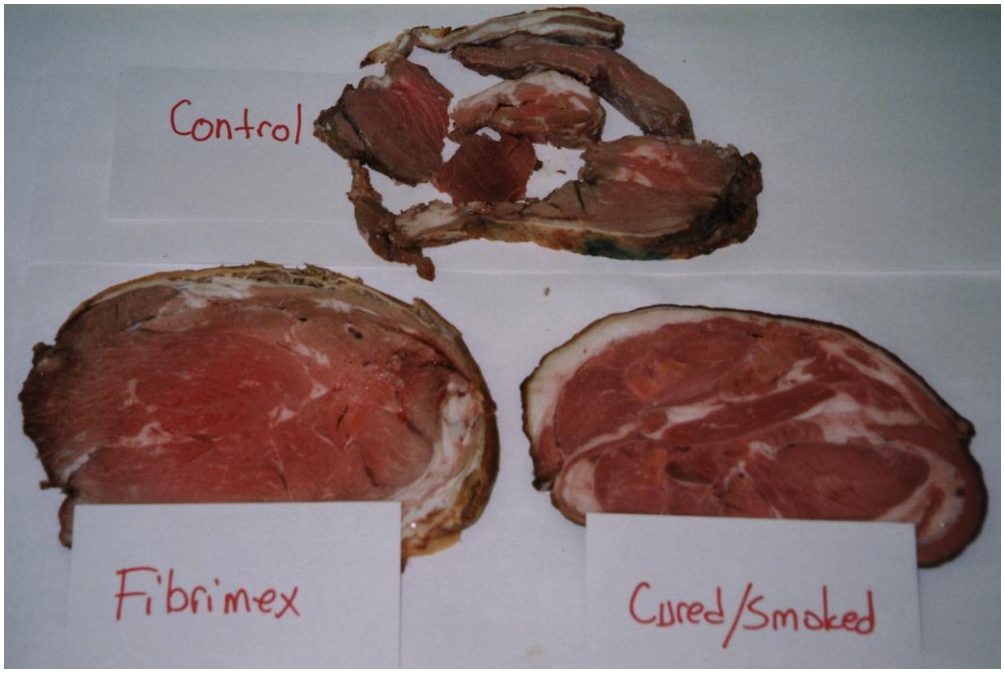
DESCRIPTION OF STEPS IN PRODUCING THE WISCONSIN LAMB ROLL

To produce a high quality Wisconsin Lamb Roll of a desired size, attention must be given to initial lamb selection. Lambs should be relatively light in weight (90-110 lbs), acceptably muscled, and trim in fat content. Heavier lambs will produce less-preferred larger lamb rolls and are more likely to carry excessive fat. Excess carcass fat requires extra labor to trim away, causes higher trimming losses (lower yields), and results in a higher fat product.

1. Split carcass into 2 sides. Remove front and hind legs.
2. Remove kidney and pelvic fat from body cavity.
3. Trim excess surface fat, blood clots, and any discolored lean from carcass. Remove fat and gristle from edge of flank.
4. Free tenderloin from backbone- - leave attached to carcass on leg end.
5. Free tail bones - - separate from pelvic bone.
6. Remove skirt muscle (lean trim).
7. Free neck meat from backbone.
8. Free meat from breast bone. Remove rib bones from the carcass, taking care not to cut through the breast.
9. Lift flank muscles from cartilage tips on lower ribs.
10. Separate back bone from loin and other back muscles.
11. Remove pelvic (aitch) bone.
12. Separate flank muscles from leg.
13. Remove leg bone - start at ball joint and follow down seam - separate at stifle joint.
14. Remove shank (boneless trim/stew meat or intact shank).
15. Remove knee cap from lower leg.
16. Remove membranes from surface of inside flank muscles.
17. Remove blade bone - - muscle laying on top of blade bone is removed for trim. Cut into junction of blade bone and arm bone - apply manual pressure to break open joint. Cut around edges of blade, and pull out/trim out.
18. Remove front shank (boneless trim/stew meat or intact shank). Come in from both sides - apply a relief cut to joint - manually break shank (pressure against table) - - finish separation with knife.
19. Tunnel-bone arm bone, starting from shank end and working towards blade bone end. Trim back heavy tendons associated with joints.
20. Remove fat pocket and lymph node in shoulder.
21. Trim interior fat pockets and outside surface fat as appropriate (including fat deposits in flank area).
22. Remove chain muscle from tenderloin.
23. Remove backstrap and heavy connective tissue and associated fat from along backline.
24. Place leg into its natural shape, and fold over into abdominal cavity.
25. Roll neck meat onto top of blade bone pocket, and fold over into chest cavity.
26. Wrap flank and breast around roast to anchor muscles in place, and provide a uniform outer surface appearance. Trim excess surface fat if necessary, but be careful not to cut through the thin flank and breast.
27. Place lamb roll into an elastic netting, or hand tie with string, to maintain proper shape for distribution and cooking.

ATTACHMENT 3
Appearance and Textural Integrity of Control (no binding agent), Fibrimex-treated and Cured/Smoked Wisconsin Lamb Rolls.

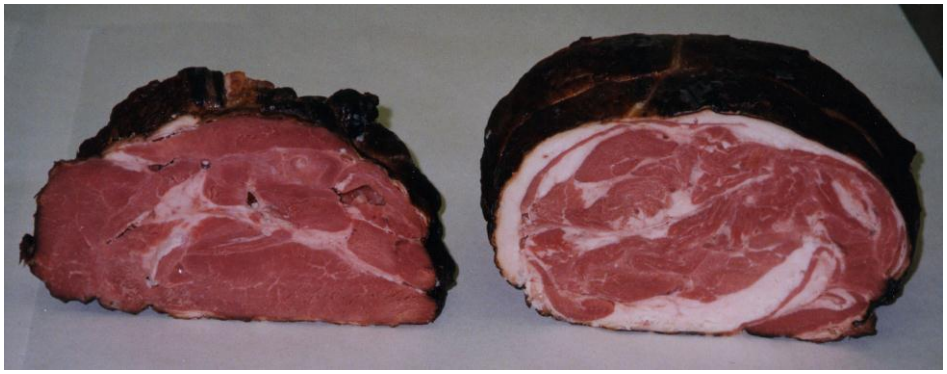
A. Intact Rolls



B. Sliced Rolls

ATTACHMENT 4
VARIATION IN LAMB ROLL COMPOSITION
Leg End (left) vs
Shoulder End (right).

A. Fibrimex-Treated



B. Cured and Smoked

ATTACHMENT 5

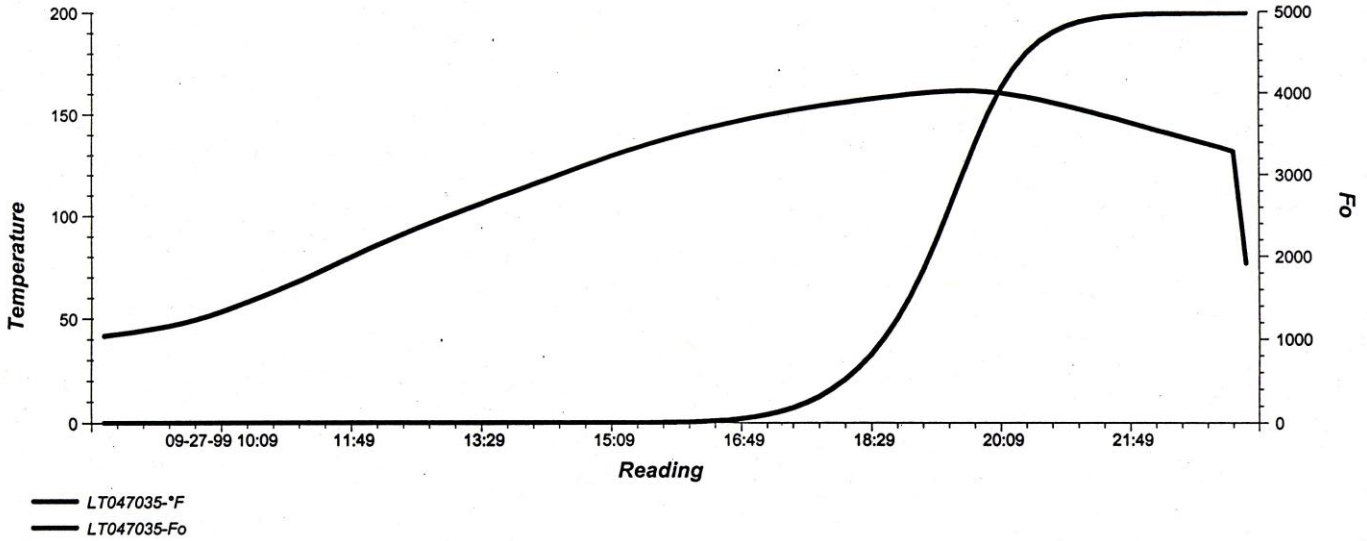
Changes in internal temperature and F-value (lethality) during cooking and smoking of cured/ smoked Wisconsin Lamb Rolls as measured by Datatrace probe.

DATATRACE

Standard Graph - Fo

Muscle Biology Lab

Figure 1. Changes in internal temperature and F-value during cooking and smoking as measured by DATAtrace probe.



LT047035-Fo 4978.01

Reading Type:	Temperature	**Run ID:**	DT000100	**Start Time:**	09-27-99
Serial Number:	LT047035	**Avg Reading:**	118.01 °F	**Value Range:**	1-89
Minimum Rdg:	41.7 °F	**Std Deviation:**	39.3093 °F	**Reading Interval:**	00:10:00
Maximum Rdg:	161.1 °F	**Fo:**	4978.0	**# Points Collected**	89

Date: 10-25-99 **Page:** 1

ATTACHMENT 6
FABRICATION OF WISCONSIN LAMB ROLL

A. Bill Blake and Erik Russell evaluate lamb carcasses.

C. Erik Russell begins deboning process.

B. Terry Timm and Erik Russell saw carcass into two halves.

D. Erik Russell continues deboning until carcass side is completely boneless.

ATTACHMENT 6 *(Cont'd.)*
FABRICATION OF WISCONSIN LAMB ROLL

E. Erik Russell instructs Mehmet Calicioglu in deboning technique.

G. Erik Russell folds together boneless lamb side, creating a lamb roll.

F. Dennis Buege applies Fibrimex (binding agent) to interior of boneless lamb side.

H. Boneless lamb roll is stuffed into netting to retain its shape through cooking.

Attachment 7

Judge Name_____ Judge Number_____

I HAVE BEEN INFORMED ABOUT THE NATURE OF FOODS IN THIS PANEL ☐

VISUAL DESCRIPTIVE SENSORY ANALYSIS

Roasted Lamb Slices

Date: June 27, 2000

Directions: VIEW each coded sample. Then, complete the ballot by placing a vertical mark along each line at the position that best describes your opinion of the sample. Be sure to write the sample number above each mark.

VISUAL APPEARANCE ATTRIBUTES:

1. **Degree of Cooking Doneness**: Please indicate your assessment of the **degree of cooking doneness** of each sample.

Undercooked, not done — Overcooked, very done

2. **Integrity (Intactness) of Slices of Meat:** Please indicate your assessment of the **integrity (intactness) of slices** of each sample.

Very fragmented, not intact — Very intact

3. **Fractures/Seams within Slices of Meat**: Please indicate your assessment of the **fractures/seams within slices** of each sample.

Limited (few) seams between meat sections — Abundant (numerous) seams between meat sections

4. **Visual Appeal**: Please indicate your assessment of the **visual appeal** of each sample.

Very unappealing — Very appealing

Comments:

Attachment 8

Judge Name_____ Judge Number_____

I HAVE BEEN INFORMED ABOUT THE NATURE OF FOODS IN THIS PANEL ☐

DESCRIPTIVE SENSORY ANALYSIS

Roasted Lamb Slices

Date: June 27, 2000

Directions: TASTE each coded sample individually, and then **place a vertical mark along each line at the position that best expresses your opinion** of the sample. Be sure to write the sample number above each mark.

FLAVOR AND TEXTURE ATTRIBUTES:

1. **JUICINESS:** Please indicate your assessment of the **juiciness** of each sample.

Not juicy — Very juicy

2. **TENDERNESS:** Please indicate your assessment of the **tenderness** of each sample.

Not tender, tough — Very tender, not tough

3. **LAMB FLAVOR INTENSITY:** Please indicate your assessment of the **lamb flavor** intensity each sample .

Mild, Lamb-like — Strong, Mutton-like

BALLOT CONTINUED ON NEXT PAGE

Attachment 9

Judge Name_____ Judge Number_____

I HAVE BEEN INFORMED ABOUT THE NATURE OF FOODS IN THIS PANEL ☐

VISUAL DESCRIPTIVE SENSORY ANALYSIS

Smoked and Cured Wisc. Lamb Roll and Boneless Ham

Date: June 30, 2000

Directions: VIEW each coded sample. Then, complete the ballot by placing a vertical mark along each line at the position that best describes your opinion of the sample. Be sure to write the sample number above each mark.

VISUAL APPEARANCE ATTRIBUTES:

1. **Overall Color Properties**: Please indicate your assessment of the **overall color properties** of each sample.

Light, pale pink — Dark, purplish pink

2. **Uniformity of Color within Slices of Meat:** Please indicate your assessment of the **uniformity of color** of each sample.

Not uniform — Very uniform

3. **Fractures/Seams within Slices of Meat**: Please indicate your assessment of the **fractures/seams within slices** of each sample.

Limited (few) seams between meat sections — Abundant (numerous) seams between meat sections

4. **Relative Abundance of Fat:** Please indicate your assessment of the **relative abundance of fat** for each sample.

Absent — Abundant

5. **Visual Appeal**: Please indicate your assessment of the **visual appeal** of each sample.

Very unappealing — Very appealing

Comments:

Attachment 10

Judge Name_____ Judge Number_____

I HAVE BEEN INFORMED ABOUT THE NATURE OF FOODS IN THIS PANEL ☐

DESCRIPTIVE SENSORY ANALYSIS

Smoked and Cured Wisc. Lamb Roll and Boneless Ham

Date: June 30, 2000

Directions: TASTE each coded sample individually, and then **place a vertical mark along each line at the position that best expresses your opinion** of the sample. Be sure to write the sample number above each mark.

FLAVOR AND TEXTURE ATTRIBUTES:

1. **Firmness:** Please indicate your assessment of the **firmness** of each sample.

Very soft — Very firm

2. **TENDERNESS:** Please indicate your assessment of the **tenderness** of each sample.

Not tender, tough — Very tender, not tough

3. **LAMB FLAVOR INTENSITY:** Please indicate your assessment of the **lamb flavor** intensity of each sample .

None — Strong

BALLOT CONTINUED ON NEXT PAGE

May 12, 2000

ATTACHMENT 11

Dennis Buege
Meats Lab
Campus

Dennis:

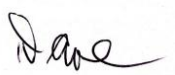
Thanks so much for cooking the lamb roll for us today. It was very good. We grilled marinated chops and ate them at about 11:30 a.m. and then ate the lamb roll about 12:20 p.m. I asked the students to rate the lamb roll on a 1-9 scale with 1 being undesirable and 9 being very desirable. This wasn't the best condition for a taste test because the student's had already eaten a meal when the lamb roll arrived. Ten students ate the lamb roll:

Juiciness – N=10, Ave.=6.5
Flavor – N=10, Ave.=5.8
Texture – N=10, Ave.=7.0

I asked them to indicate their preference for the chops or roll:
7 preferred the chops, 2 preferred the roll (I lost one student here and only had nine responses).

The roll held together very well and came off in very nice slices. It seemed to me that there was just a little more fat in it than I would prefer. If you were not partial to fat, you would probably have trimmed some fat out of the slice as you ate it. Three members of the farm crew joined us at the end, and raved about the roll and had several servings. They thought it was a great product and wanted to know where it could be obtained.

Sincerely yours,



David L. Thomas
Professor of Sheep Genetics and Management
and Sheep Extension Specialist